VACCINE COOLER FOR DEVELOPING COUNTRIES

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Abstract

This project designed a portable vaccine cooler for the distribution of vaccines in developing countries. It is designed as an insulated box that limits heat transfer from the containment unit to the outside ambient conditions. The vaccine cooler is comprised of a peltier device, heat sinks, fan, phase change material (PCM), and foam board insulation. Finite element analysis (FEA) is used to assist the design of the thermal insulation and PCM layers. The simulation results show that the designed foam insulation board can effectively reduce heat transfer from outside air to the vaccine chamber and the PCM materials can help maintain the chamber in the desired temperature range for at least 5 days.

Customer Needs

Distribution of heat-sensitive vaccines is a challenging task in developing countries, especially the rural communities with limited or no electrical power [1]. Vaccine coolers are often used for "last-mile" transport of vaccines by humans walking, on bicycles or on motorbikes [2]. These factors are considered in designing a vaccine cooler:

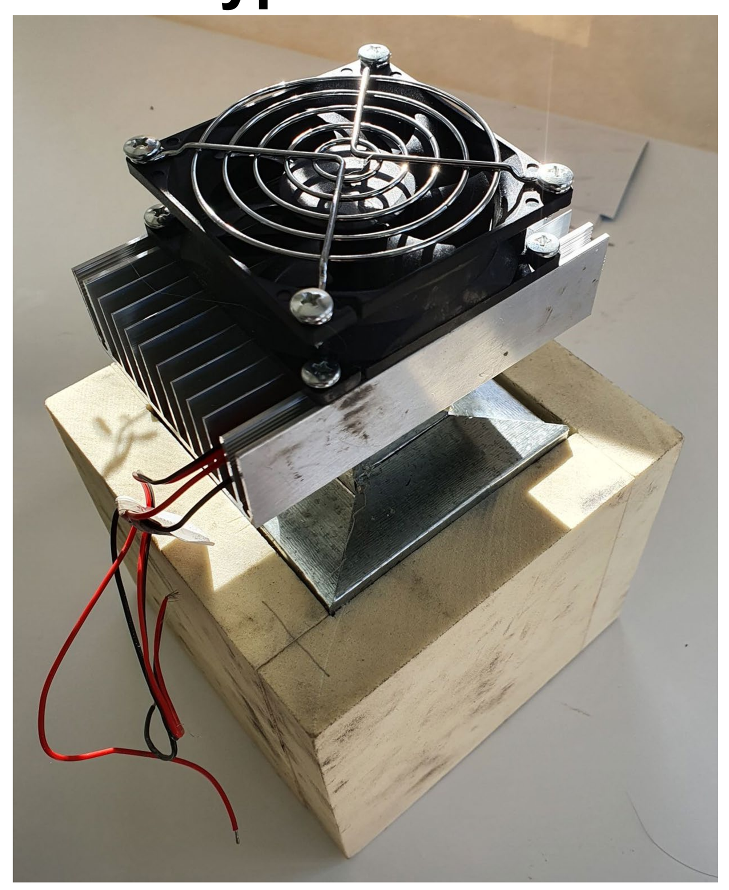
- Ease of maintenance
- Light weight/portable
- Low cost
- Carrying capacity
- Passive cooling
- Charging capability

Temperature Requirement For A Vaccine Cooler

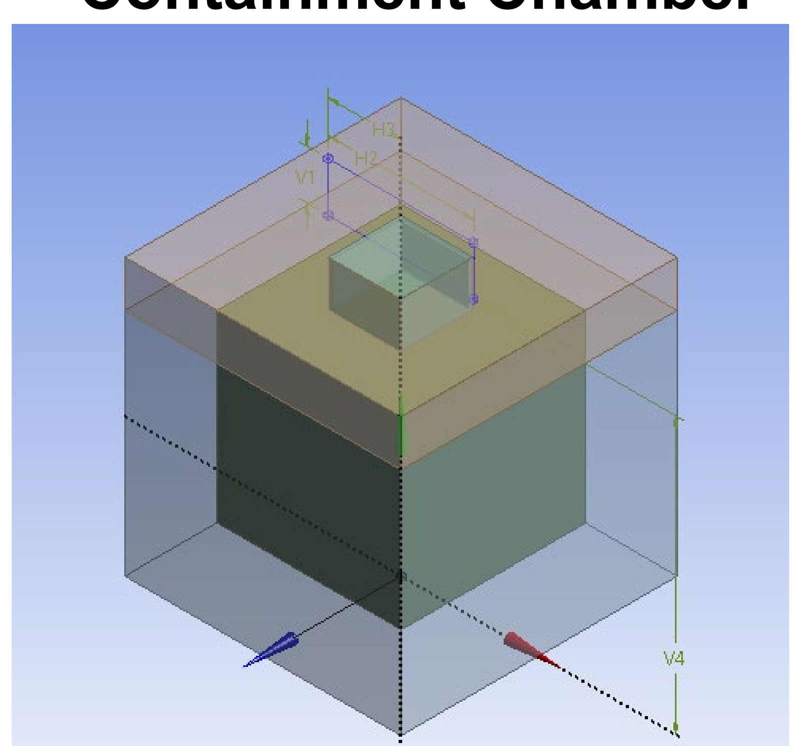
Vaccines are a temperature sensitive material that require a specified temperature while in transportation. If the containment section becomes too cold it risks freezing the vaccine while on the other hand if it is too hot it will become impotent.
The required temperature range for vaccines is between 2°c -8°c [3].

Mechanical Concept Design

Prototype of the Cooler



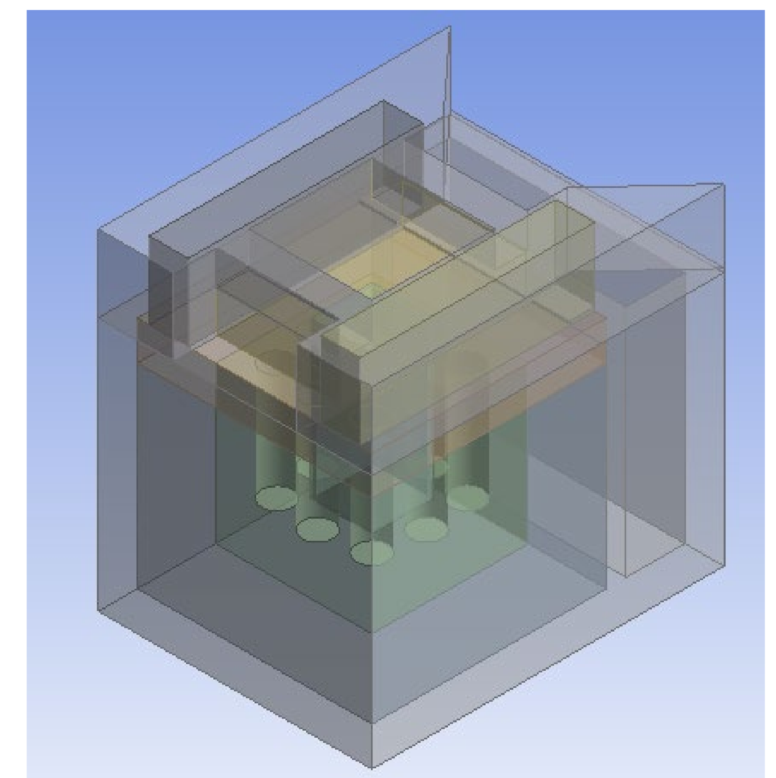
Containment Chamber



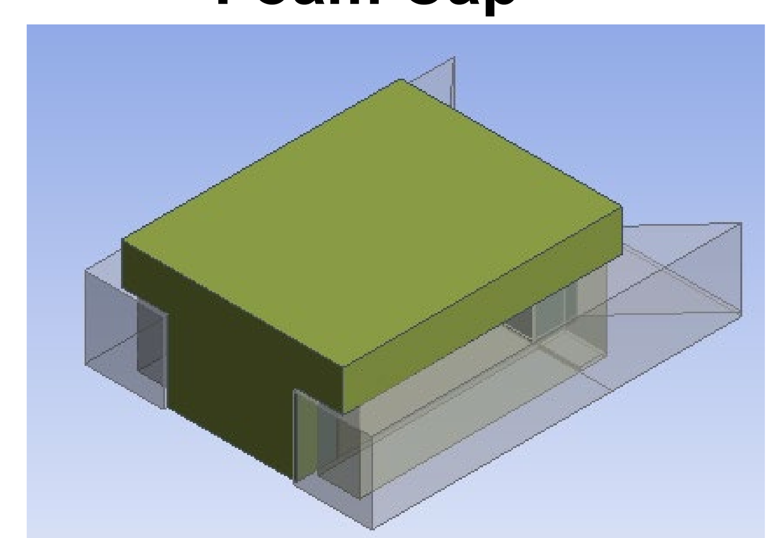
The vaccine cooler is designed to keep the temperature of vaccines between 2-8 °C for 2-3 days after with a charged phase change (PCM) layer and a thermal insulation layer between the vaccine chambers and the outside air. The PCM is charged by a peltier thermoelectric cooler. The image on the left shows an unfinished prototype of the vaccine cooler. The right image is the CAD model of the cooler without the peltier cooler.

- **Peltier** plate cold side is connected with **an aluminum armature** to charge the PCM
- Peltier plate hot side is connected to a **heatsink** for heat dissipation to ambient air
- A form insulated **containment chamber** is created to house the aluminum armature and PCM.
- A **foam Cap** is created to be placed on top of the heat sink when the peltier system is inactive: this is to prevent heat transfer through the peltier system when it is not active.

CAD Model of the Cooler



Foam Cap



Finite Element Analysis

A transient thermal model as shown in Figure 1 was developed and simulated in ANSYS Workbench to study the effectiveness of thermal insulation by the foam and the capability of maintaining vaccines at constant temperature by the PCM. It is found that the foam layer is effective to reduce heat transfer from outside ambient air. The PCM is found to fully melt around 4 days and remain cold after 5 days as shown in Figures 2 and 3.

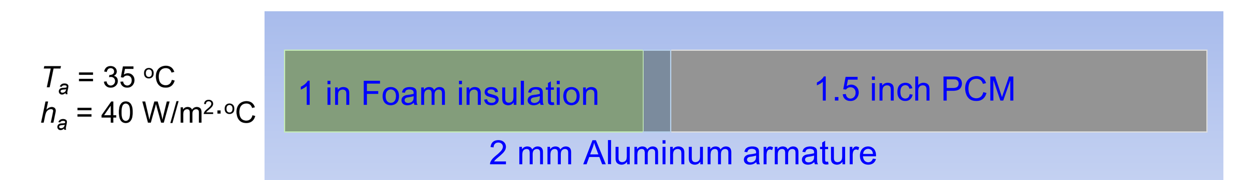


Figure 1 Simplified Geometry for FEA model.

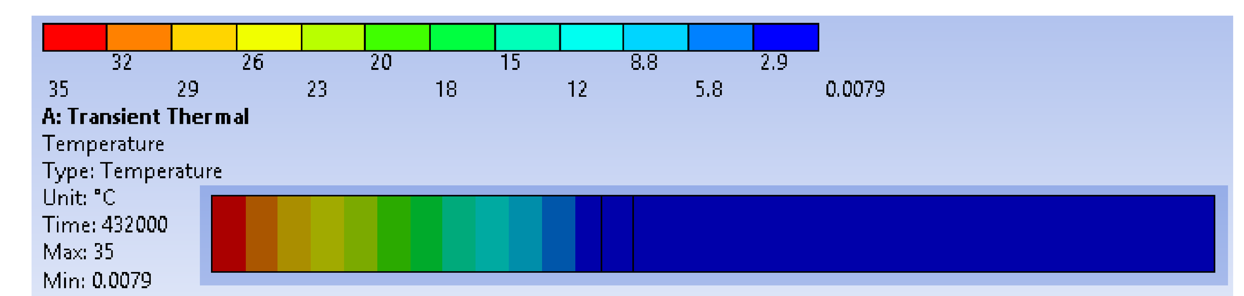


Figure 2 temperature distribution at the end of 5 days.

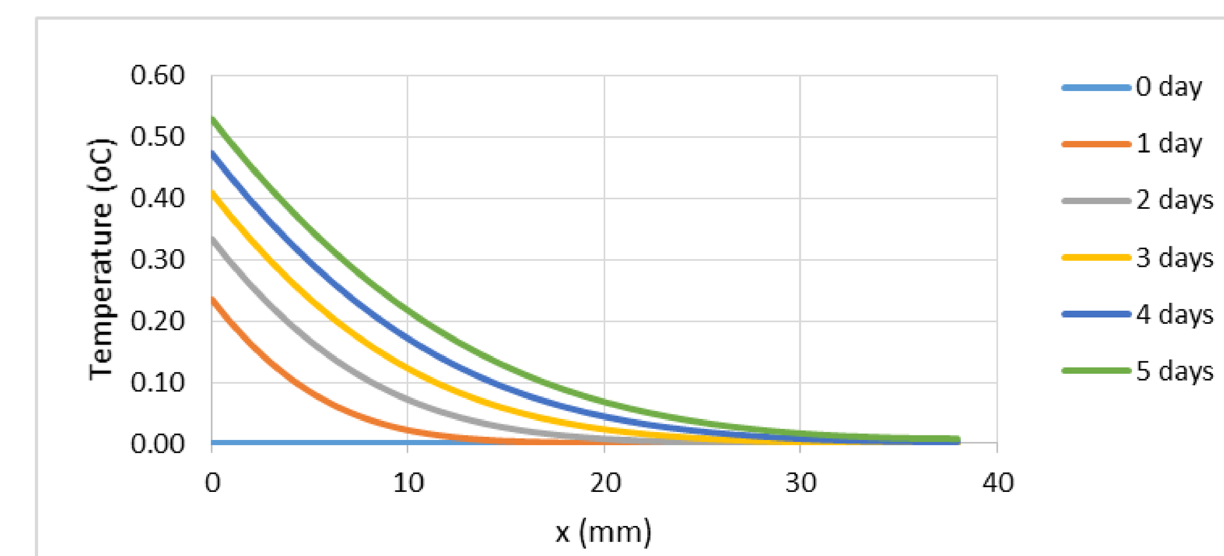
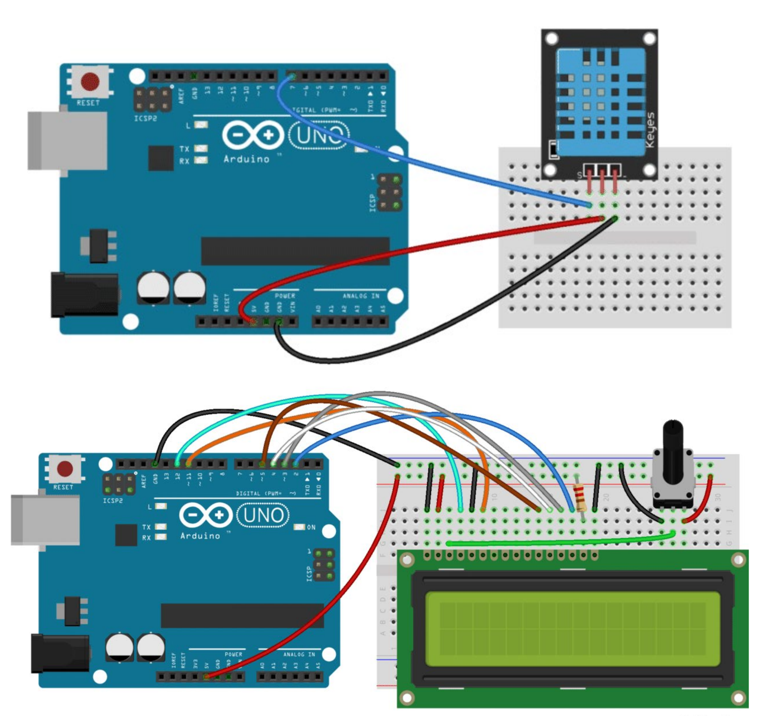


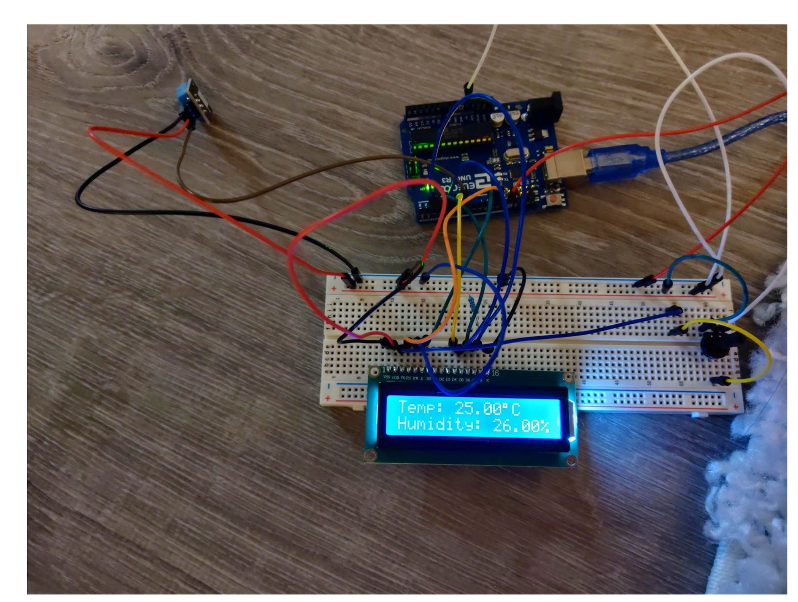
Figure 3 Temperature profiles of PCM at different time instants.

Electrical Components



A circuit is created to monitor the temperature of the PCM (Created By Nhat Pham).

It will be used to measures temperature and displays it on an LCD display.



References

1. "COVID-19 Vaccine Could Revolutionize Cold Storage around the World." *UN Environment*, UN Environment Programme, 9 Dec. 2020, www.unep.org/news-and-stories/story/covid-19-vaccine-could-revolutionize-cold-storage-around-world"
2. Larson, Benjamin J, et al. "Vaccine Cooler for the Global Poor." *DigitalCommons@CalPoly*, Cal Poly, May 2019, digitalcommons.calpoly.edu/mesp/498/.
3. *Vaccine Storage and Handling Toolkit* . Centers for Disease Control and Prevention, 2020.